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ABSTRACT

Two rural counties served as model areas in a comparison of the size and sequence of socioeconomic changes that investment in communications, as opposed to investment in transportation networks, might stimulate. A series of communications, rail, and highway changes were simulated through the use of an econometric model. An Industrial Communication Index was used to project the influence of communications on plant location and output. The simulations for 1975 through 1990 showed that communications investments led to larger, more dispersed, and cumulative impacts than did transportation investments. The findings support the view that communications improvements can enhance economic development, influence location decisions, and be used to forecast the location of output for some industries. (FL)

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ABSTRACT

INVESTMENT IN COMMUNICATIONS AND TRANSPORTATION: SOCIO-ECONOMIC IMPACTS ON RURAL DEVELOPMENT

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The paper compares the size, extent and sequence of socioeconomic impacts resulting from simulated investment in transportation and communication within two rural counties. Highway and rail improvements generate lower marginal shipping costs. An Industrial Communication Index and methodology are developed to measure the regional availability of economic activity in communication and information. The ICI projects the influence of communication on plant location and output. The 1975-1990 simulations, using Professor Harris' model, show communication investment leads to larger, more dispersed and cumulative impacts than transportation. A Chow test indicates significant changes for employment, income, gross regional product and population at 1% level.

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I. Introduction

The federal government has long had a policy committed to the concept of subnational economic development. This commitment is evidenced by the creation of administrative agencies such as the Appalachian Regional Commission, the Economic Development Administration and the Title V Regional Commissions. These are supported through the programs authorized by the Public Works and Economic Development Act of 1965 with 1974 Amendments, the Rural Development Act of 1972 and the Regional Development Act of 1975. Particular attention has been directed towards the problems of rural Americans and their need for both equity in the receipt of services and greater equality of opportunity for socioeconomic development.

This paper is concerned with assessing the relative effectiveness of alternative programs aimed at achieving these development goals. In particular, the paper focuses upon a comparison of the rural growth impacts that investment in communication as opposed to transportation networks might stimulate. The intent is to identify the relative size and type of changes as well as the extent and sequence of linkages to other sectors that transportation and communication investments might have within typical rural communities.

II. Current Views on Investment Impacts.

Existing research reveals conflicting views regarding the development impacts resulting from investments in transportation or communications. In particular, there is a question as to whether such investment stimulates growth *per se* or supplements it without generating additional progress.

The theory of central places (Emerson & Lamphere, 1975, Ch. 6) incorporates both the traditional Weberian supply and a real demand or

market aspects of firm location. Given Variations in minimum market size for specific goods, the theory projects a regional hierarchy which dictates the service area, structure and function for production. In addition, agglomeration advantages such as reduced interfirm transfer costs, scale economics, economics of labor specialization and professional interaction operate to make centralized locations attractive. Within this context, transportation improvements allow firms to serve a wider geographic area thus further intensifying the tendency towards centralized location.

A recent Department of Commerce survey (U.S. Congress, Senate, Committee on Agriculture and Forestry 1975, p.157) of 3,000 firms confirms the importance of accessibility and transportation costs as elements in plant location decisions. In another study of Maine industries Mandell, (1975) showed that transportation and distance disadvantages can be compensated for by the advantages of rural living.

Conversely, Straszheim (1972, p. 213) questions the fact "that location models appear to reflect a degree of 'rationality' or 'normative' behavior which is too simple an abstraction in comparison to what we know of firms' determinations of actual locations." He cites a University of Michigan study (Mueller, Wilkens and Wood, 1961, P. 16) which indicated that personal reasons or chance influenced the location decisions of 50 percent of the firms surveyed.

A comparable degree of ambiguity exists with respect to the relationship between transportation investment and rural development. The 2,630 mile Appalachian Development Highway System was a major element in that region's revitalization program. Subsequent research (Preston Associates, 1970, p v.) supported the hypothesis "that industrial develop-

ment follows highway investments." Alternatively, Straszheim (1972, p.212) believes that because America's transportation system is already quite developed, opportunities for transport policy to shape regional development are reduced substantially. A complementary view is expressed by Vary Coates (1974) who questions the wisdom of a national rural transportation policy as the key to the future of small towns. Using the theory of central places, Coates argues that if accessibility is increased as a result of transportation investments, this will support the aggregation of economic functions rather than enhance the locational attractiveness of rural communities.

With the Regional Rail Reorganization Act of 1973, the economic impact of railroads on rural economies has received increased scrutiny. The national rail planners and state officials have compiled very unlike results from impact studies on the abandonment of light density lines (e.g., branch lines with light traffic density). With few exceptions, these lines are located in rural areas. The diversity in results can be attributed to differences in the methodology, assumptions, and data sources utilized by these researchers.

In its Preliminary System Plan (PSP), the United States Railway Association (USRA) presents data on the potential overall impact from termination of problem line rail service. For these potentially excess lines, the report estimates a very small impact upon the economic base of the affected counties. The study (United States Railway Association, 1975, p. 334) concludes: "In short, even the most pessimistic estimates of the adverse impacts on the Region and areas within the Region indicate that the effect of the suggested reduction in the size of the rail system would be negligible."

Eastern State's estimates of the impact of abandonment of light density lines on rural areas differ considerably from those of USRA. In particular, the New York Rail Task Force (undated), addressing the restrictions and limitations of various methods of evaluating impacts and rail costs, was able to refute the claim of unprofitability of many branch lines suggested for abandonment by USRA.

The Commonwealth of Pennsylvania Department of Transportation (PENN/DOT) report (1975) is critical of the work compiled by USRA because of two major conceptual errors which undermine the results obtained. With an alternative methodology, the PENN/DOT analysis of USRA proposed abandonments found extreme and unnecessary burdens forced upon the communities served.

With the aforementioned studies and those done for other states (Public Interest Economic Center, 1973: Secretary of Transportation, State of New Jersey, 1974), it is reasonable to assume that these studies might provide some clue as to the role of rail system development in rural areas, but they do not. At best, "those studies look at the impact for a year after abandonment in terms of changes in employment, wages, and so forth; two-year or five-year projections into the future are almost nonexistent in such studies, and as a result, future development impacts are not examined"(The Council of State Governments, 1975, p. 46).

In attempting to identify the development impacts of communications, two researchers, Parker and Porat (1975, p. 10) note that "the basic structural change that has taken place in the economy since 1950 is the growth of information occupations relative to industrial occupations". Computer and telecommunications technology developments, among others, are bringing about these structural changes. As the authors point out, transpor-

tation networks and electric utilities currently provide a basic infrastructure potential for regional economic development. Government policies, furthermore, could promote the construction of a computer-communication infrastructure, and this, no doubt, would enhance economic development, (Parker and Porat, 1975, p. 44-45).

A supporting view (Ploman, 1975) notes that industrialized nations are aware of the problems and opportunities presented by new communication technologies. What they lack, however, is an overview of communications and communications systems in formulating policy. Also, Ploman (1975, p. 93-94) is concerned about achieving a systematic approach to communications policy and planning through reliance on existing theories: "If, at one end of the scale, telecommunications have a close relationship with transportation, (then) at the other end of the scale they merge with mass communication and the mass media. Here we find not only that the concept of mass media is being questioned, but also that it is being extended to the point of making clear the need for new concepts".

Although developments in communications have been very rapid recently, the public sector, in general, and certainly the rural regions, in particular, have experienced very little of the impact. Businesses, institutions, and urban areas have benefited from developments in transmissions systems. This lack of balance in the distribution of the impact of new communications technology promotes information-rich and -poor status differentials.

The information-rich, described by Katzman (1974, p. 53) as economic and informational status rather than personal ability, tend to outdistance the information-poor more and more as new communications techniques are introduced. Programs designed to ensure that the inform-

nation-poor also benefit from such advances and developments must rest on public policy commitments to that goal.

As is noted by Schramm and Lerner (1976), communication geared to development can not and does not occur in a social and economic vacuum. In such recent research, the mass media are seen as having the potential of widening knowledge and adoption gaps between the advantaged and disadvantaged segments of the society. Tichenor (1970), termed this discrepancy "the knowledge gap." More recently this discrepancy has been called the "communication effects gap".

For Goldmark (1973), the future health of the U.S. society depends on reducing urban and rural inequities. He believes that telecommunications technology can be utilized in rural areas to upgrade the quality of life. Communications should enable rural regions to improve education, health care, entertainment, and job opportunities. This will help them to retain their existing population as well as attract new residents from urban areas.

A survey study of Connecticut businesses by the New Rural Society Project (1973, p. IV-3) reveals that for most manufacturing firms "communications systems do not appear to have had a significant influence on location choices." However, anticipated communications problems were often mentioned as one factor influencing the decision against relocation. The quality and number of personal contacts between the staff and the industry as a whole were feared to be inadequate in a rural area.

As the U.S. moves further along into a post-industrial economy, the role of communications-oriented firms is increasingly enhanced. In the opinion of Machlup (1962, p. 7-8, 32-33), these firms belong to a class known as "knowledge industries." The product of such industries

in in part the disclosure and distribution of available but "subjectively new knowledge."

III. Exogenous Policy Choices and the Simulation Model

Site Selection

Two rural counties were chosen to serve as the model areas for transportation and communication impact simulation. Because there is only limited information on the linkages between improvements in accessibility and the socioeconomic reaction (if any) within a community, the simulations focused upon areas with a subjectively determined take-off potential. The rural designation is consistent with the one developed by the Congress when specifying eligibility for industrial and business loans under the Consolidated Farmers Home Administration Act. The Act defines rural areas as all territory other than that within cities of 50,000 or more and their suburbs (U.S. Congress, Senate, 1975, p.292).

Model regions of county size were chosen due to the existence of Census data on this level and the ability to simulate a physical area that is potentially manageable from a policy perspective. Acceptability was determined through a combined review of 1960 as well as 1970 Census data and a series of on-site meetings with local officials and employers. In addition, a county classification system developed by Chinitz (1969, pp. 52-61) was consulted for initial screening.

The two areas, Indiana County (1970 pop. 79,451) in Western Pennsylvania and Pitt County (1970 pop. 73,900) in Eastern North Carolina, are alike in terms of their present economic base and their need for improved access to the nearest metropolitan area. There are three tiers to the economic structure of each county. Both possess significant extractive activity with Indiana producing bituminous coal and Pitt being

the nation's largest grower of flu-cured tobacco. Both counties have an important industrial sector that accounts for approximately 20 percent of total employment. Finally, each county includes a university level employment sector.

The two counties are also similar in their communications characteristics. Both have an educational television station. Pitt has five and Indiana has six television signals bringing in the three major networks. In Pitt, 98 percent of the households have television which is slightly larger than the Indiana figure of 95.7 percent (Standard Rate and Data Service, Spot Television Rates and Data, June, 1975). This compares to the national average of 96.8 percent. Both communities have daily newspapers. The Greenville Reflector has a daily circulation just short of 13,000 while the Indiana Gazette has a daily circulation of slightly more than 18,000 (Standard Rate and Data Service, Newspaper Rates and Data, June, 1975).

The telephone systems of both are comparable in sophistication. Currently, long-distance equipment is a combination of OIN (operator-assisted) and AIN (automatic). While there is neither ESS (electronic switching) or a 911 emergency service, touch-tone service is available on a limited basis. Both local offices (Bell of Pennsylvania and Carolina Telephone and Telegraph, a non-Bell affiliate of United Telephone) state that they are able to provide any specialized service such as WATS, microwave, data service, wide band service and ITFS (Instructional Television Fixed Service).

Some differences between the communities do appear in the areas of cable penetration and the availability of local radio signals. In Pitt, 9.5 percent of the homes are covered by cable television while in

Indiana, this figure rises to 29 percent. With respect to radio coverage, Pitt has 4 AM and 2 FM stations. Indiana possesses one of each. However, both counties receive numerous outside signals.

Given these two test counties and their initial conditions, a series of hypothetical communications, rail and highway changes were simulated through the use of an econometric model to determine the nature and extent of regional growth.

Rail Costs and Investment

To ascertain the effect of upgrading rail service on rural development, one must first determine the appropriate form of railroad investment. This requires an analysis of the four subcomponents of railroad costs as they apply to freight movement. Terminal charges are for loading and unloading cars, assembling trains, etc., within railroad yards. Line-haul charges are for the movement of freight from one geographic place to another. Loss and damage charges cover breakage, spoilage and other damage to shipments. These three items are variable costs, which change according to the number of units shipped. Constant (or fixed) costs cover the railroad's cost of plant and equipment.

Data is available on these components of railroad freight charges per service unit, and on the number of service units, at the national level. Data is also available for freight moving within and between the Official, Southern and Western regions of the United States. The site areas selected for study, Indiana County, Pennsylvania and Pitt County, North Carolina, lie within the Official and Southern regions, respectively.

To determine the cost of moving freight within each county, the freight costs per unit are assumed to be the same as for the county's

respective region. These costs must be multiplied by the appropriate number of service units -- average train length, tonnage and trip length. Average train length and tonnage for trains travelling through the county are assumed the same as for the appropriate region. Trip length, however, is reduced from the average length for the region to the average trip length to traverse each county. These average train-trip lengths were determined through an analysis of the proportion of through-trains and way-trains traversing the region within which the county lies, and on the length of track to be upgraded. The total cost figures for an average train traversing each county are shown in Tables 1 and 2.

[Tables 1 and 2 about here]

Given the size of the geographic region analyzed (counties), an appropriate railroad investment to increase the attractiveness of rural sites would be in imporving rails and rail beds. This investment would affect the line-haul component of variable cost.

With the initial line-haul charge of shipping an average freight train over a specific length of track in the county and the present time to complete such a trip, one can derive the county line-haul cost per hour. Rail investment would increase the maximum allowable speed for a train over a length of track. Assuming changes in rail cost are completely passed on to rail users, any reduction in freight travel time due to rail investment multiplied by the county line-haul cost per hour will furnish the dollar reduction in county variable line-haul cost.

The Federal Railway Association (FRA) has safety standards for track of specific rail status. The FRA maximum allowable freight operating speeds for various track classes are: (1) Class I - 10 mph; (2) Class II - 25 mph; (3) Class III - 40 mph; (4) Class IV - 60 mph; (5) Class V-

Table 1

Total Cost of Shipping By Rail Within Indiana County, Pennsylvania, 1975

Terminal	Cost/Unit (in cents) (1975)	Service Units (1975)	Total Cost (in dollars) (1975)
Per Car	14695.568	69.8	$10,257.51
Per Ton	3.0545	4209.	128.56
(1) Total Terminal			$10,386.07
Line Haul			
Per Car-Mile, Way Train	64.0712	69.8 x 34 x .1292	$ 196.45
Per Car-Mile, Through Train	51.8021	69.8 x 34 x .8708	1,070.53
Per Ton-Mile, Way Train	.8642	4209. x 34 x .0803	99.31
Per Ton-Mile, Through Train	.4437	4209. x 34 x .9197	583.97
(2) Total Line Haul			1,950.24
(3) Loss and Damage	16.14	4209	179.33
(4) Variable Cost (Sum of 1,2,3)			$13,015.66
Constant Cost			
Per Ton	81.517	4209	$ 3,431.05
Per Ton-Mile	.4623	4209 x 34	661.58
(5) Total Constant Cost			$ 4,092.63
Total Cost (4+5)			$17,108.29

Sources: Freight cost figures are derived from data contained in the Interstate Commerce Commission, Procedures for Developing Rail Revenue Contribution by Commodity and Territory, Year 1965 (Washington: Government Printing Office, 1968). These costs were estimated for the year 1975 by employing the Railroad Freight Price Index as found in the Survey of Current Business, 1976, page S-24. Finally, service units were derived from data in the American Association of Railways, Yearbook of Railroad Facts (Washington, 1975), pages 25, 29, 38, and 41.

Table 2

Total Cost of Shipping By Rail Within Pitt County, North Carolina, 1975

Terminal	Cost/Unit (in cents) (1975)	Service Units (1975)	Total Cost (in dollars) (1975)
Per Car	10275.866	69.4	$ 7,131.45
Per Ton	2.8984	5615.	162.75
(1) Total Terminal			$ 7,294.20
Line Haul			
Per Car-Mile, Way Train	55.5704	69.4 x 24.86 x .2611	$ 250.33
Per Car-Mile, Through Train	44.6167	69.4 x 24.86 x .7389	568.78
Per Ton-Mile, Way Train	.6506	5615. x 24.86 x .3344	303.69
Per Ton-Mile, Through Train	.4285	5615. x 24.86 x .6656	398.12
(2) Total Line Haul			$ 1,520.92
(3) Loss and Damage	22.94	5615.	$ 1,288.08
(4) Variable Cost (Sum of 1,2,3)			$10,103.20
Constant Cost			
Per Ton	63.7132	5615.	$ 3,577.50
Per Ton-Mile	.4973	5615 x 24.86	694.18
(5) Total Constant Cost			$ 4,271.68
Total Cost (4+5)			$14,374.88

Source: See Table 1.

110 mph.

For two counties the required improvements to upgrade track one rail class status were quite different. In Indiana County, there is rehabilitation data available on one rail line which runs from Black Lick Junction to Indiana, Pennsylvania (Department of Transportation, Commonwealth of Pennsylvania, 1975, p. 326.2). This track does not presently meet FRA Class I rail status. To upgrade this track to Class I status would require the replacement of rail ties and the repairing of a number of grade crossings. Extrapolating from available data, and using a Transportation Equipment Index to adjust these figures (Bureau of Economic Analysis, 1975), a 1975 dollar figure was estimated for the cost of upgrading 36 miles of track through Indiana County. Assuming this investment is undertaken through borrowing for 25 years, at 7% interest, the amortized total cost of this rail improvement would be $1.1 million dollars. In Pitt County, the major rail line presently has an FRA Class II rail status. Correspondence with Southern Railroad officials indicates that to upgrade this line to Class III status would require laying 115 pound new welded rail, releasing 80 pound jointed rail, and installing 900 crossties per mile. For the entire 28.5 miles of track through Pitt County, the amortized total cost of this rail improvement would be $5.9 million dollars.

The effect of this rail improvement is to reduce the time to complete a rail trip from 5.8 to 3.4 hours in Indiana County, and from .99 to .55 hours in Pitt County. This reduction in hours times the line-haul cost per hour yields the county line-haul cost savings due to rail improvement. For the Harris simulation model, the line-haul charge reduction must be translated into a comparable reduction in terminal cost,

e.g., line-haul cost savings as a percentage of terminal cost. As a result of the aforementioned rail improvements, the percentage reductions in terminal charge for Indiana and Pitt Counties are 7.77% and 9.27% respectively.

Highway Costs and Investment

The test for the significance of road improvements as a force in rural development was based upon a hypothetical upgrading of specific routes to Interstate Highway standards. This served to increase highway speeds with a corresponding reduction in travel time to and from the sample communities. Next, the time savings which enhanced the geographic accessibility of the sites were translated into lower truck travel costs. Finally, these economic alterations were introduced within the simulation model to estimate their impact of industrial location and employment decisions.

The roads were selected on the basis of existing state highway department plans and a series of interviews with local planners and business leaders. These improvements represent the types of design and accessibility changes which would have to be made if the communities were to achieve better motor contact with major external sites. The routes designated for analysis via simulation are as follows. In Pitt a 39 mile stretch of U.S. 264 costing $87,143,274. In Indiana a 39.7 mile portion of U.S. 119 costing $136,654,480, a 30.66 mile stretch of U.S. 422 costing $98,172,731 and 18.21 miles of U.S. 20 costing $60,800,000.

Given the routes identified for upgrading, the next step was to determine the elasticity of transportation costs with respect to speed. There are two aspects to this discussion. The first involves the data estimations and computations. The second focuses upon the relationship

between costs and speed using regional ICC data, (Interstate Commerce Commission, 1960-70).

In each of the ICC regions (Southern for Pitt and the Middle Atlantic for Indiana), the following 1970 data was collected:[2]

A. Line haul cost per vehicle mile by speed;

B. Out-of-pocket expenses for pickup and delivery, platform and handling and billing;

C. Pickup and delivery vehicle miles and hours.

Estimates were needed for pickup and delivery and terminal costs for the different line haul speeds. This would allow for the calculation of total cost per vehicle mile at different speeds. To get these estimates, the ICC out-of-pocket expenses for pickup and delivery and terminal charges (which includes platform, handling and billing expenses) for 1970 were divided by the miles for pickup and delivery in the ICC survey years of 1960 (1961 for the Southern Region), 1964 and 1970.

This computation with the expenses kept constant at the 1970 level allowed the variation in sample year pickup and delivery vehicle miles to reflect changes in the region's highway system. A log linear relationship between line haul speeds (in the sample years), adjusted by the percentage change in pickup and delivery speed and these costs per sample year miles was estimated to get the slope and intercept coefficients. These are shown in Table 3 equations 1 and 2 for each region. The coefficients and the line haul speeds were used to estimate the 1970 pickup and delivery and terminal costs per vehicle mile at different line haul speeds. Total cost per vehicle mile for the different line haul speeds was then calculated by summing line haul, pickup and delivery and terminal costs per vehicle mile.

[Table 3 about here]

Table 3

Equations and Resulting Coefficients

(1) $\ln PD^S = 6.4641 - 1.7766 \ln(AL)_t^S$

$\ln PD^M = 7.1103 - 1.9558 \ln(AL)_t^M$

(2) $\ln TM^S = 6.4242 - 1.7767 \ln(AL)_t^S$

$\ln TM^M = 6.7683 - 1.9558 \ln(AL)_t^M$

(3) $\ln(TC)^S = 6.1430 - .6689 \ln(L)^S \quad R^2 = .9886$

$\ln(TC)^M = 6.3703 - .6763 \ln(L)^M \quad R^2 = .9944$

Notation

S = Southern Region

M = Middle Atlantic Region

PD = 1970 Pickup and Delivery Costs per sample year pickup and delivery vehicle mile ($70/VM^t)

TM = 1970 Terminal Costs (Platform and Handling + Billing) per sample year pickup and delivery vehicle mile ($70/VM^t)

TC = 1970 Total Cost (PD + TM + Line Haul) per vehicle mile

L = Line Haul Running Speed

AL = Line Haul Speed adjusted for the P + D speed.

t = the sample year used

The data points for total cost per vehicle mile and line haul speeds were then plotted and showed not a linear relationship but more of a logarithmic relationship. The equation estimated was total cost per vehicle mile as a logarithmic function of line haul speed. These results are shown in Table 3 as the third group of equations. The slope coefficients show the elasticities in that a 1% increase in line haul speed will result in .6685% decline in total costs in the Southern region and a .6763% decline in the Middle Atlantic region.

The final step in estimating the impact of the improvements involves an assignment of each county's total traffic flows. Using available origin and destination information and population data, it was estimated that the U.S. 264 upgrading in Pitt would carry in the neighborhood of 40.3% of the total traffic flow. A similar estimate for the three road projects in Indiana yielded a figure of 80.6% of total truck traffic.

In assembling the above data components, the following procedure was used to estimate the overall percentage reduction in trucking costs associated with the improvement.

% reduction in truck travel costs	=	% increase in truck speeds	x	Speed elasticity of truck travel costs	x	Fraction of truck traffic affected by improvement

The calculations lead to the conclusion that the improvement will generate a reduction of truck travel costs averaging -17.36% in Indiana and -8.58% in Pitt.

The Simulation Model

The Harris model is a multi-regional, multi-industry forecasting

tool, (Harris, 1973). Starting with a national forecast for a set of aggregate socioeconomic variables, the model allocates geographically the level and changes in the level of output in up to one hundred and three employment sectors. The impetus for the allocation involves industrial location which is determined by costs and agglomeration effects. A special version of the model was developed for the U.S. Department of Transportation, (Harris, 1974). Using the DOT's TRANSNET routing model, along with a linear programming algorithm, this version traces out the regional economic impacts of alternative transportation expenditures.

The model combines orthodox economic assumptions regarding industrial location with a Ricardian view of land rents. It assumes that improved transportation enhances the accessibility of a region by altering marginal shipping costs. A locational rent accrues to firms located in that region relative to competitors located elsewhere. As other firms in the industry notice this locational advantage, they will tend to move there causing a rise in employment. This leads to population increases, income growth and higher consumer expenditures accompanied by multiplier effects.

Clearly, not all employment sectors are affected equally by transportation improvements. The impact on service sectors would be indirect. In addition, firms that are dependent on rail would benefit little from highway improvements.

A complete review of the model's system of equations is beyond the scope of this summary. However, the driving force of the model is the equation that explains the changes in output for each employment sector. The general form (Harris, 1974, p.35) is:

$$QD_{ij}^{t} = f_i\,(TQ_{ij}^{t-1},\ TI_{s_kj}^{t-1},\ WR_{ij}^{t-1},\ VL_{j}^{t-1},\ Q_{ij}^{t-1},\ EQ_{hj}^{t-1},\ MB_{ikj}^{t-1},$$

$$MS_{ikj}^{t-1},\ GGS_{j}^{t-1},\ DEN_{j}^{t-1})$$

WHERE:

QD_{ij}^{t}	The output (less defense expenditures of industry i located in region j in year t;
TQ_{ij}^{t-1}	The transport cost of shipping a marginal unit of output from industry i out of region j in year t-1;
$TI_{s_kj}^{t-1}$	The transport cost of obtaining a marginal unit of input k in region j in year t-1;
WR_{ij}^{t-1}	The annual earnings per worker in labor sector i workings in region j in year t-1;
VL_{j}^{t-1}	The value of land in region j in year t-1;
Q_{ij}^{t-1}	The output of industry i in year t-1;
EQ_{hj}^{t-1}	Equipment purchases by equipment sector i in year t-1;
MB_{ikj}^{t-1}	Major buying sector K in region j that bought goods from industry i in year t-1;
MS_{ikj}^{t-1}	Major supplying sector K that sold goods to industry i in year t-1;
GGS_{j}^{t-1}	The highway congestion index in region j in year t-1;
DEN_{j}^{t-1}	The population per square mile in region j in year t-1;

Communications Index and Policy

Another location parameter, the Industrial Communication Index (ICI), was added to the Model sensitizing it to the level of economic activity in communication and information industry sectors. Identifying economic growth, particularly rural, as a function of communication improvements is an innovative approach to development. While the ICI is only an exploratory application of this concept within an econ-

ometric forecasting model, it promises to provide a methodological tool of much potential for communication research.

The ICI is a measure of the regional availability of economic activity in communication and information. Data needed for its computation are the regional output and demand of each of the six (6) communication sectors identified within the Harris model. Regional demand includes communication use by all industries, consumers, and government. The six communication sectors are defined below:

Sector 34: Printing and Publishing

Includes: newspapers, periodicals; book printing and publishing; commercial printing (letterpress, litho, plate, gravure); business forms, greeting cards; binders and binding; typesetting, photoengraving, electrotyping, litho platemaking.

Sector 61: Office and computing machines

Includes: typewriters, electronic computing equipment, calculators, scales and balances; general office machines.

Sector 66: Communication equipment

Includes: radio and television receivers; phonograph records; telephone and telegraph equipment; radio and television transmitters and apparatus.

Sector 76: Communications

Includes: telephone and telegraph utilization; other communication services (cable, microwave, etc.).

Sector 77: Radio and television broadcasting

Includes: radio and television broadcasting services and facilities.

Sector 83: Business services

Includes: title abstracting services; advertising agencies and outdoor advertising services; radio television and publisher representatives; credit reporting and collection; mailing, reproduction and steno services; building services; repair services; legal

services; engineering and architectural services; noncommercial research organizations.

The ICI represents the difference between the supply of and the demand for communications in a region. In general terms, the ICI can be stated as follows:

$$ICI_j^t = \sum_{k=1}^{6} S_{kj}^t - \sum_{k=1}^{6} D_{kj}^t$$

WHERE:

ICI_j^t	Industrial Communication Index in Region j at time k
S_k^t	Supply of communication industry sector k output in region j at time t
D_{kj}^t	Demand for communication industry sector k output in region j at time t
k	Communication industry sectors, k=6
	k_{34} Printing and publishing
	k_{61} Office and computing machines
	k_{66} Communications equipment
	k_{76} Communication
	k_{77} Radio and television broadcasting
	k_{85} Business services

The ICI measures the surplus or deficit in the amount of economic activity in communication sectors k in region j at time t through the use of the formula:

$$ICI_j^t = \sum_{k=1}^{6} Q_{kj}^t - \sum_{k=1}^{6} \sum_{k=1}^{99} (a_{ki}^t \times Q_{ij}^t) + \sum_{k=1}^{6} PCE_{kj}^t + \sum_{k=1}^{6} \sum_{h=1}^{8} (g_{kh}^t \times GOV_{hj}^t) + \sum_{k=1}^{6} DEF_{kj}^t.$$

WHERE:

i	All industry sectors, including communication, i=99
a_{ki}^t	Input-output technical coefficient (national scales from

	industry k to industry i per unit of output for industry i) in year t
Q^t_{ij}	Output of industry sector i in region j at time t
PEC^t_{kj}	Personal consumption expenditures for communications sector k in region j in year t
g^t_{kh}	Government coefficient (national sales from industry k to government function h per unit total government purchases by function h) in year t
GOV^t_{hj}	General (non-defense) government expenditures, excluding construction and employee compensation, by function type h located in region j in year t
Q^t_{kj}	Output of communication industry sector k in region j at time t
DEF^t_{kj}	Defense expenditures for communication sector k in region j in year t

This research reflects the view that communication improvements can enhance economic development, influence location decisions, and be used to forecast the location of output for some industries. As constructed, if a region has a large positive value for its ICI, industries dependent on communications would be attracted to the area. On the other hand, a negative value of ICI would discourage other industries.[3]

The output of industry sector i in region j at time t and the general government expenditures in region j at time t were weighted by national technical coefficients to ensure structural similarity of the industry sectors at the regional level to that existent at the national level. The assumption was made that forced regional investment based on policy decisions would of necessity approximate the national situation. This decision could be taken as merely inflating the level of regional investment, but for a first test of the ICI this was the policy adhered to.[4] The decision to adhere to the assumption that forced regional investment would of necessity approximate the national situation was based on a review of the available research on the pattern of economic support

for the mass media in relation to the general economy. The constancy hypothesis proposed by Scripps (1965, p. 4) states that the pattern of economic support for the mass media has been relatively constant and is more closely related to the general economy than to changes and trends within the mass media field itself. Scripps suggests that mass communications has become a staple of consumption in our society.

According to McCombs (1972, p. 61), the Principle of Relative Constancy has been substantiated by the events of the past four decades. "Only a small and fixed proportion of the economy is available to finance mass communication. Over the years the pie has grown, but at the same rate as the economy which produced the pie was growing."

Based on these observations, the assumption of structural similarity of the regional to the national sectors appeared to provide a best fit given the constraints of the Model and of the available data base.

The exploratory application of the ICI in the Harris Model follows the "with and without investment" method for the evaluation of locational impact. First, the Model is run with a given time horizon to establish baseline forecasts. No assumption is made regarding exogenous changes in the independent variables.

Second, policy changes reflecting investments in communication are incorporated. In this simulation, the exogenous component for each communication sector was based on the difference between the 1975 supply and demand figures. These differences were generated internally by the Model and are shown in Table 4. The ICI values also appear in Table 4.

[Table 4 about here]

If demand exceeded supply in 1975, the exogenous output was added in each year to the endogenous output that would be forecast normally as in the

Table 4

1975 Supply, Demand, and ICI values Computed for Pitt and Indiana Counties

County		Sec. 34	Sec. 61	Sec. 66	Sec. 76	Sec. 77	Sec. 85	Total
Pitt	Supply (000)	5656.	72612.	271.	411.	0.	0.	78949.
	Demand (000)	3697.	683.	1831.	4778.	321.	21357.	32667.
	Differ (000)	1959.	71929.	-1560.	-4367.	-321.	-21357.	*46283. = ICI
Indiana	Supply (000)	15136.	8789.	825.	899.	0.	0.	25649.
	Demand (000)	2333.	808.	2332	4027.	268.	18942.	28710.
	Differ (000)	12803.	7981.	-1507.	-3128.	-268	-18942.	-3061.= ICI

* Difference due to rounding

baseline run. Investment equations in the Model estimated the capital expenditures needed to produce the additional output in communications. On the second run of the Model, the time horizon used was that of the baseline run; this run simulated the socioeconomic impact of the communication investments. The differences between the two sets of forecasts for each year indicate the impact of such investments.

IV: Empirical Results

The computer output from the Harris model lists twelve variables as indicators of a county's economic performance. A shortened version of the results is shown in Table 5. The normal forecast is based upon a long-term national estimate of economic growth. The Harris model allocates this growth to the various industries within each study site.

[Table 5 about here]

The transportation and communication forecasts differ from the normal forecast in two respects. First, the level of investment in transportation or communication is increased beyond that of the normal forecast to allow for improvements in rail and road or communications. This investment occurs in the 1976-77 period. Prior to that period, the three forecasts are identical. During this investment period, there is a short-term response, revealed through the twelve economic variables, due to construction. Second, once construction or improvements are completed, the transportation and commmunication forecasts incorporate the reductions in shipping costs or cost-saving communication changes due to investment, and the computer output indicates the effect of these changes on the location decisions of firms. These long-run effects occur primarily during the 1981-90 time period.

Table 5

	Computer Simulations - Indiana				Computer Simulations - Pitt			
	Normal		Trans-portation	Communi-cations	Normal		Trans-portation	Communi-cations
	1970	1990	1990	1990	1970	1990	1990	1990
Total Jobs	23824	25786	25751	28111	27261	37407	37367	41484
Civilian Persons Employed	22393	24260	24227	26445	21122	29077	29046	32302
Civilian Labor Force	23000	25346	25346	27653	23351	31343	31278	34818
Civilian Unemployment Rate	5.9%	4.3%	4.4%	4.4%	9.5%	7.2%	7.1%	7.2%
Population	79452	78085	78114	85211	73901	89623	89157	99219
Percent Non-White	.8%	1.0%	.9%	1.0%	34.7%	39.0%	39.0%	38.6%
Personal Income ($000)	239593	344498	344137	380946	187302	355813	355072	412089
Per Capita Income	3018	4412	4406	4471	2534	3970	3983	4153
Gross Regional Product ($000)	256508	378042	374115	443557	275449	619523	618409	722648
Personal Consumption Expenditures ($000)	135758	176681	178995	209151	135868	263600	262960	315585
Private Investment ($000)	40041	61865	61828	68056	34431	64716	64633	74877
Government Expenditures ($000)	73411	119167	119119	126607	61878	121889	121712	133477

To separate the short- and long-term effects of investment, the data was divided into two time spans, 1970-78 and 1981-90, for analysis. The data on each of twelve variables, for each time period and forecast, was analyzed using regression (time series) analysis. For each variable and time period, three regression coefficients were estimated which indicated the rate of growth over time of the variable in each of the three forecasts. To determine whether there is any significant effect of investment in the two counties, one has to ascertain whether the regression coefficients for the: (1) normal vs. transportation, and (2) normal vs. communication forecasts are significantly different. This can be accomplished through the use of the Chow test (Chow, 1960, p. 591-605) which tests the equality between regression coefficients in two models based on two different data sets.

For the 1970-78 time period, the regression coefficients for the: (1) normal vs. transportation and (2) normal vs. communication forecasts are not significantly different. The growth in jobs, and thus, income, population and gross regional product, that did occur due to transportation investment in the two counties is a result of construction. In the investment period (1976-77), approximately 60% of the new jobs in Indiana County and 70% in Pitt are attributable to the construction industry. The government sector accounts for a large portion of the remaining new jobs in the 1977-78 period. Additionally, there are some expanded job opportunities in: (1) wholesale trade, (2) food store, and (3) eating and drinking establishments.

The pattern of growth for the communication investment forecasts differs substantially from that for transportation. The business services industry show the largest increases in both counties. Approximately

45-55% of the communication investment created jobs are in this industry. Also, unlike the transportation forecast, the remaining new jobs are dispersed throughout a majority of the other industries of both counties.

The direct impact of transportation and communication investment can also be viewed through a comparison of changes in the four sets of economic variables. In Indiana County, the direct result on jobs, population, income, and gross regional product was more substantial; the effects were three or four times as large, but also more centralized, for transportation than communication investment. In Pitt county, although more job dispersion again occured due to communication changes, the magnitude of the changes in the four sets of economic variables were quite similar for these two forecasts during the investment period. This centralization vs. dispersion of new jobs is relevant, and its long-run effects on these counties become clear when the 1981-90 period is analyzed.

Prior to this long-run analysis, however, it is necessary to explain the lack of significant differences in the regression coefficients for paired forecasts. First, there were five observations on which the regression coefficients were determined. Since the initial investment occurred in the years 1976-77, two of the five observed years, 1970 and 1975, have exactly the same values for the variables in all three forecasts. Any effect of investment would alter the forecasts only in the last three years, and only the direct investment effect would be indicated. Second, the level of direct investment in the 1976-77 period, especially in transportation, was small relative to either the normal level of private investment or gross regional product for the counties. Thus, due to the overlapping forecasts, the fact that solely direct in-

vestment is considered, and that investment was a small percentage of private investment, the regression coefficients were not significantly different for the paired forecasts.

The long-term effects of alterations in transportation and communications over the 1981-90 period are significantly different as shown by the results of the Chow test in Table 6.

[Table 6 about here]

A review of the F statistics indicates that the magnitude of the long-run multiplier effects of communication investment is manyfold larger than for transportation. For either county, the communication improvement significantly, at the 1% level, increases the regression coefficient for each economic variable over what that coefficient's value was for the normal forecast. Thus, a significantly more rapid rate of economic growth occurs in the communication forecast. Improved transportation in Pitt County has no significant effect on the economic variables, and only selective effects in Indiana County. What difference there is between the normal and transportation forecasts indicates that total jobs, population, income, and gross regional product is actually lower in Pitt County by 1990 in the transportation forecast. For all but the population aggregate, the same general result is exhibited for Indiana County. The major industry in which contraction occurs is Real Estate and Rental in Indiana, and Medical and Educational Institutions in Pitt. Both these industries would be strongly affected by the initial construction-related population growth and the decline in that variable over time.

V. Policy Implications

Although the figures are only a simulation subject to the limitations imposed by the data base, the structural assumptions of the model

Table 6

F-values for the Test of Significance of the Difference Between Two Regressions Coefficients, Paired Forecasts, Pitt and Indiana Counties, 1981-90

Variable	Transportation vs. Normal Forecast	Communication vs. Normal Forecast	Transportation vs. Normal Forecast	Communication vs. Normal Forcast
Jobs	4.02 *	178,121. ***	12.83 **	29.93 ***
Civilian Persons Employed	1.07	37,688. ***	6.51 *	12.30 **
Civilian Labor Force	.33	711.98 ***	3.65	1,112. ***
Civilian Unemployment Rate	.08	0.	1.84	5.84 *
Population	1.40	363.56 ***	1.54	539. ***
Personal Income	.28	1,915. ***	9.63 **	3,272. ***
Per Capita Income	2.70	170.73 ***	1.70	23.19 ***
Gross Regional Product	.77	3,234. ***	18.55 ***	25,933. ***
Personal Consumption Expenditures	1.84	380. ***	44.11 ***	2,499. ***
Private Investment	.58	7,283. ***	4.19	980. ***
Government Expenditures	.20	1,296. ***	138.28 ***	1,260. ***

Note: * Significant at the 10% level
** significant at the 5% level
*** significant at the 1% level

and the accuracy of the policy inputs, a few cautious observations are in order.

The first has to do with the rather disappointing results of the transportation investment. Not only was the immediate reaction heavily concentrated in the construction sectors, but the lasting influence as recorded in the terminal year showed a net reduction in job opportunities for both communities. Apparently, any initial development momentum was quickly lost as a result of either the existing structural deficiencies of the counties or their proximity to superior production points. The results provide added support for the contention that physical access and locational improvements reinforce economic concentration as opposed to dispersion.

If transportation investment is to serve as an agent in the development process, then more pre-construction attention must be directed towards identifying the specific employment opportunities which are targeted for growth. Additional community efforts (manpower training, tax concessions, zoning changes, etc.) may be necessary to capture the intended benefits. Transportation investment alone appears insufficient.

The second observation deals with the extent, size and time sequence of communications related rural growth. By the 1990 terminal year, all but six out of thirty-six employment groups have experienced a rise within Pitt. In Indiana County the no response figure increases slightly to nine. For some groups such as chemicals the expansion in communications leads to the introduction of important new industries and employment possibilities.

With respect to impact size, the 2325 new jobs in Indiana were spread over eight employment groups which experienced more than 100 new

openings. The leading sectors here were medical and educational institutions as well as business services. The indication is that substantial gains might be experienced by wide segments of the economy.

From a planning perspective, the time sequence of the growth process provides useful information in addition to the identification of linkages. Wtih limited local resources, data on timing can guide officials in anticipating the chain of development activity. This allows them to concentrate attention and supplemental efforts when and where they are most needed. For example, the simulation shows an immediate need to expand state and local government services as well as wholesale operations. On the other hand, the growth of hotel and other services is a slower process which peaks in the terminal year.

The net effect of these observations may very well be to intensify public interest in employing communication systems to stimulate rural development.

NOTES

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2. The following estimates were developed with the assistance of Professor Harris and his staff.
3. The ICI and the supply and demand values are generated by the Model for all runs.
4. This procedure was followed even though no coefficient is obtainable within the Harris Model for personal consumption expenditures.

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